Agricultural Research, Technology and Policy:

Innovations and Advances

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Artificial Intelligence in Agriculture

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Abstract

Artificial intelligence or AI in the decision-making system is nothing but computer science and machines that produces rational reasoning like the human brain. We are grateful generation to exist in this age of technological advances in which computers, algorithms, and various automated machines take up most of the activities. Artificial Intelligence (AI) and Machine Learning (ML) are increasingly being adopted by agriculture in terms of both agricultural products and in-field farming techniques. In order to improve productivity and efficiency, AI technology supports various sectors of agriculture. AI solutions facilitate Smart irrigation, precision planting, intelligent harvesting, automatic pest monitoring, safe analysis of storage and delivery, and usage analytics of agricultural products. This chapter addressed the present status, growth, and contribution of AI in sustainable development in the Agriculture sector in India. To encounter the problems facing the farmers, hope that AI should make its mark in order to boost the status of farmers.

Keywords: Agri Start-up, Agriculture, Artificial Intelligence (AI), Automated Machines, Drone, Precision Farming, Sensors, Smart Agriculture

1. Introduction

Artificial Intelligence (AI) is a field of computer science which deals with the simulation of human intelligence in intelligent devices that are capable think and perform simple to complex tasks like a human with greater efficiency and less error. The main purpose of artificial intelligence consists of learning, reasoning, and perception. The term "AI" was introduced by John McCarthy in 1956 at The Dartmouth Conference. Semantics study of the word "artificial intelligence" composed of two words; first "artificial" means made by human effort, not produced naturally; second "intelligence" means the ability to understand and perform the task. Due to AI, machines are able to learn itself from past experience and according reshape their skills to a new task similar to human intelligence. The phrases Artificial Intelligence, Machine Learning, and Deep Learning all are applied in the same meaning. But certain differences exist among these concepts (Gilpin *et al.*, 2018). Machine Learning is the subsets of Artificial Intelligence and Deep Learning is a subset of Machine Learning. So, Deep Learning is the most powerful and advanced version of AI. Machine Learning requires constructing algorithms that can alter themselves by feeding through organized data without human interference to enhance its performance. Deep Learning consists of algorithms that are generated that operate close to machine learning, but there are several layers of certain techniques of which provides a different understanding of the data it relies on.

There are three types of artificial intelligence found in the literature; Artificial narrow intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Super Intelligence (ASI). In ANI, machines have the potential to execute a task autonomously without human intervention. It is also known as "Weak AI". Examples: Google map, Google Assistant, Google Translate, Siri, *etc.* AGI refers to the ability of a machine that can acquire and perform any intellectual task as like human brains. It is also known as "Strong AI". At this stage, AI reaches human level intelligence and

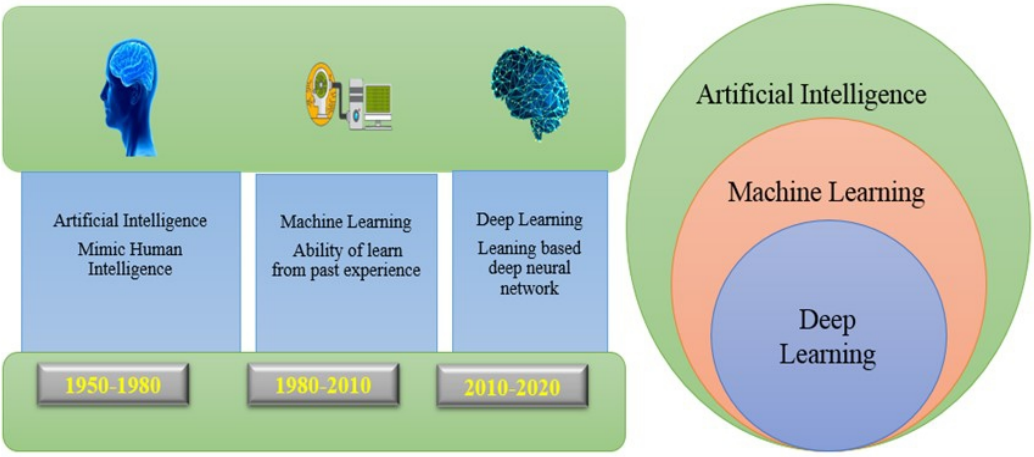

Fig. 1. Artificial Intelligence, Machine learning, and Deep learning

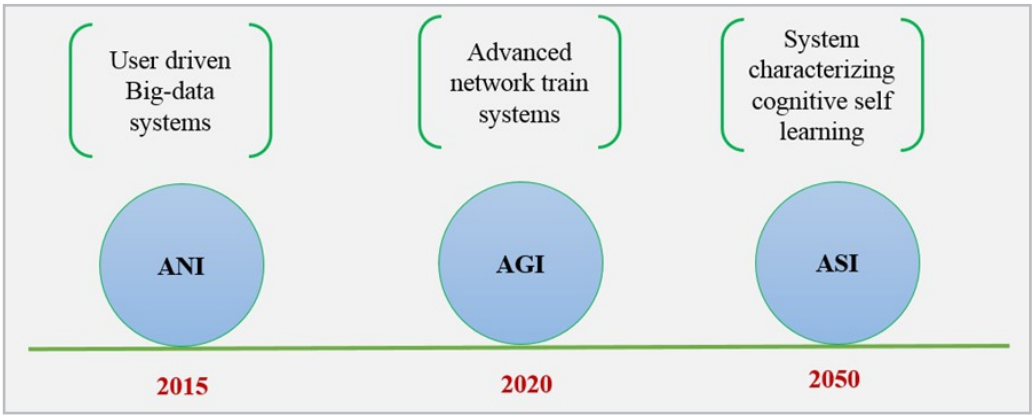

Fig. 2. Stages of Artificial Intelligence

has the ability of strong reasoning, decision making, and thinking. ASI is the most advanced and smartest intellect that is the collective intelligence of the smartest humans in every field. Artificial intelligence can operate large amounts of data sets with faster speed, simultaneous execution, and intellectual algorithms (Girasa, 2020; Manaware, 2020). This ability of AI makes it automatically from past information in form of input data sets.

The main field for food security, nutritional security and sustainable growth, and alleviating poverty is agriculture in India. It offers approx. 14% of the Gross domestic product. The Indian agricultural industry significantly contributed to the world food trade. Agriculture accounts for 10% of the nation's exports and therefore India is the fourth largest exporting primary class product country. (Manaware, 2020; Indian Agriculture and Allied Industries Industry Report, 2020). Milestones in agriculture development in India include: Green revolution, Evergreen revolution, Blue revolution, White revolution, Yellow revolution, Biotechnology revolution and the most recent one is the Information and communication technology revolution. To create a prosperous future across diverse parts of the world, modern agriculture faces enormous challenges. Examples of these global threats include a rise in population, industrialization, a rapidly polluted ecosystem, a rising shift to livestock protein intake, and of course, climate change. India is the second-largest country (after China) with respect to population. Our population is very rapidly increasing. The Indian population will grow to 2 billion by 2050, as per the UN Food and Agriculture Organisation. In order to sustain the growing population, we have to grow 70% additional food by 2050 (Gori and Tomar, 2020). And it is difficult to meet these requirements to generate 70 percent more food by 2050 as only 4 percent of land seems to be under agriculture. Global efforts will need to be handled in a manner that would not jeopardize the potential of agriculture, animals, and ecosystems to meet the globe's food requirements. Climate-change uncertainties, combined with the possibility of increased dependency on inefficient farming activities, can contribute to agricultural instability. In this situation, Artificial Intelligence is the most potent way to fulfill our dreams of zero poverty. AI forewarn the pests and disease infestation and also

gives the forecast about weather parameters such as precipitation, temperature, relative humidity, wind speed, *etc.* (Sinha, 2020). AI also a very powerful tool for improving food chain supply and reducing farm workloads. In India, smartphone reaches 30 million farmers and it is anticipated that it increase three times and 315 million rural people will be in touch with the internet by 2020 (Kumar *et al.*, 2020). AI and associated farm services are expected to have an effect on 70 million farmers by 2020, contributing the US $ 9 billion to farming' profits. (Manaware, 2020).

With the growing popularity of Artificial Intelligence like robotics, sensors, and satellites, AI has made its mark in agriculture. In the next section, we chronologically discuss the development of AI in world research.

2. Global status of artificial intelligence in agriculture

An attempt has been made to explore the global research trends, with the help of the research database of Web of Science. From 1998 to Nov 2020 research publication data has been collected from Web of Science through the keyword "Artificial Intelligence" and "Artificial Intelligence in Agriculture". By analyzing the data we find that publications related to Artificial intelligence have been increasing over the years. There is a remarkable steep rise in the year 2018 and 2019.

According to the Web of Science, there are 92232 research publications present in the literature from 1998 to 2020. Out of which only 5.55 % are related to agriculture. Agriculture is the third largest contributor to AI research.

Research interest in Artificial Intelligence in Agriculture around the world is increasing at a very high speed (Approx. 125%).

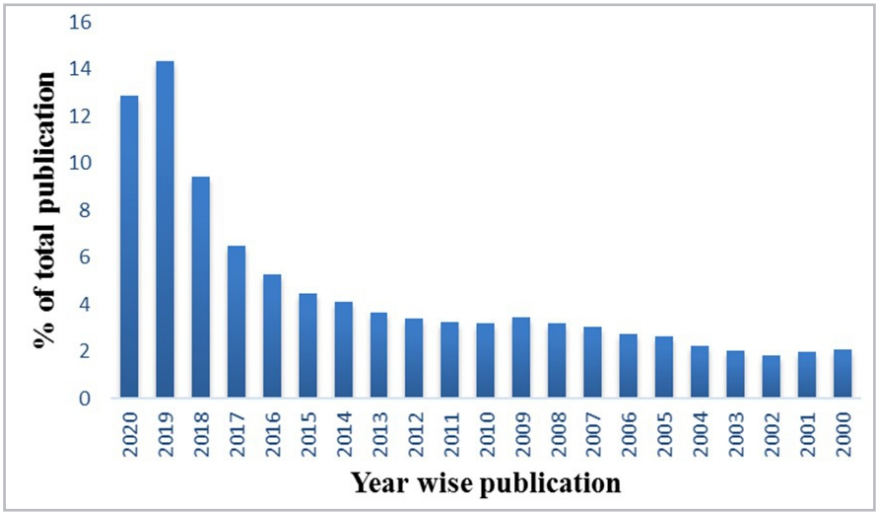

Fig. 3. Year wise trends of research on AI

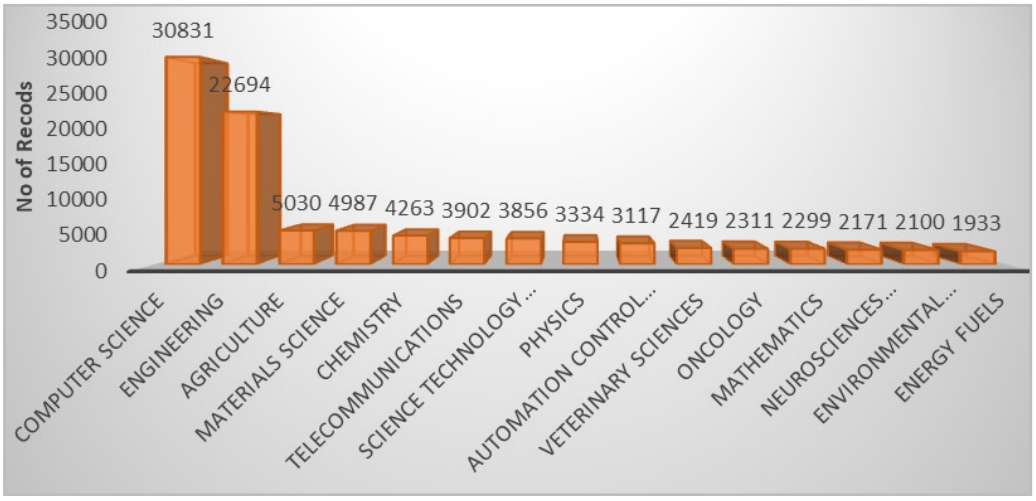

Fig. 4. Area wise contribution to research on AI

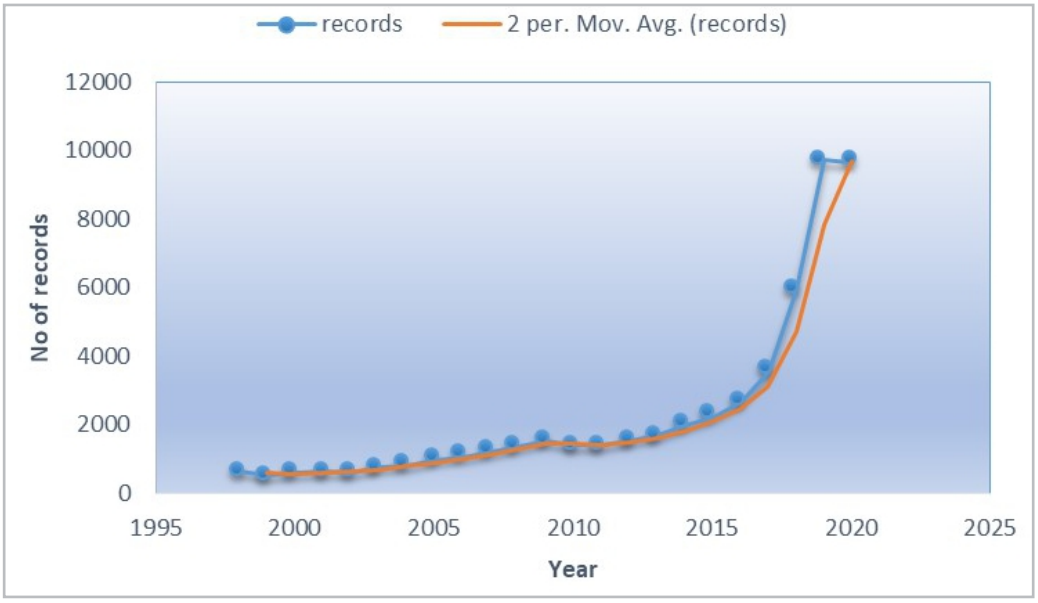

Fig. 5. Time trends of research on AI in agriculture

Fig. 6. Country wise contribution to research on AI in agriculture

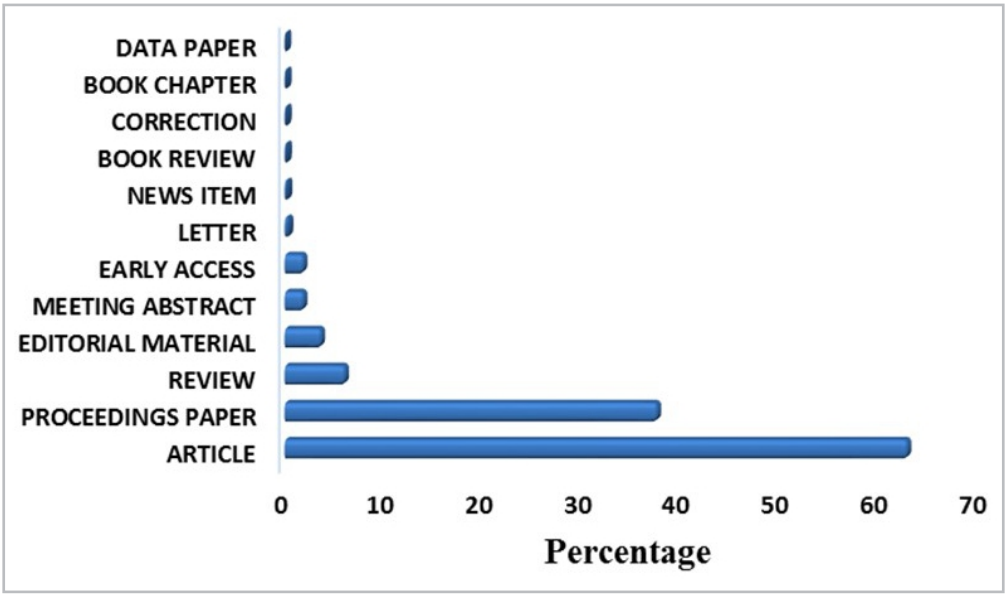

Fig. 7. Published documents type of research on AI in agriculture

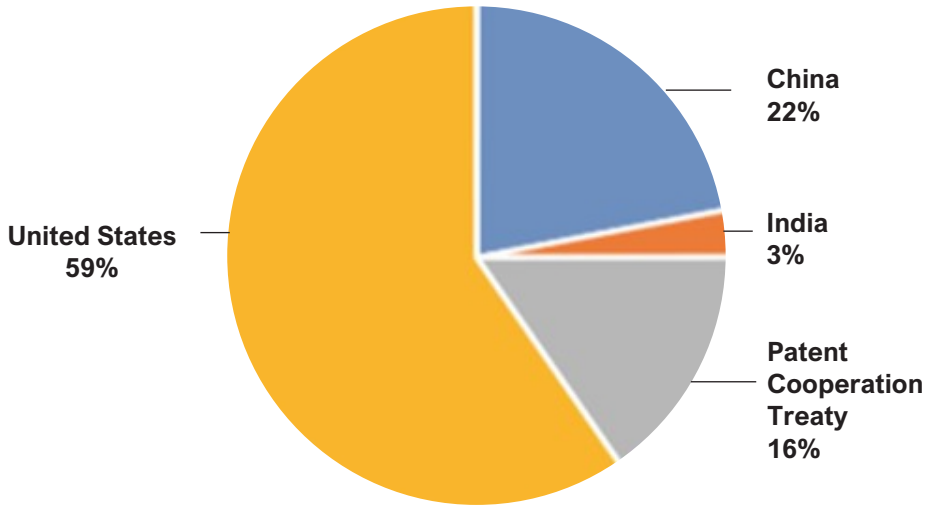

Fig. 8. Patent application in Ai in agriculture (Source: WIPO, 2018)

If we observe country wise contribution in research in Artificial Intelligence in Agriculture, find that India shares 6.22% of the total publication till date. India stands in the fourth position succeeded by the USA, China, and England in terms of publication.

In another interesting fact we find that among all published documents from 1998 to 2020, Articles are 62.86% followed by proceeding papers, review papers, *etc*.

An analysis of the World Intellectual Property Organization (WIPO) finds that USA contributes around 60% of patent filing in the field of Artificial Intelligence in agriculture followed by China (22%). India shares only 3% in total patent filing (ICAR).

The growth of AI technology in agriculture is remarkable in the last decades. This growth is highly beneficial for the world as well as for India.

3. Application of artificial intelligence in agriculture:

3.1. Automated irrigation systems

Automated irrigation systems are a smart way to irrigate agricultural crops by using the precise amount of water and minimal involvement of manpower. Automated irrigation systems composed of a centralized decision making system that control irrigation command based on the sensors to surrounding parameters. The sensor systems help centralized the decision making system by indicating the condition of crop water, usage of crop water, and soil water levels in real time (Fangmeier *et al.*, 1990).

Advantages of Automated irrigation system

- Reduce the cost of cultivation
- Increase crop yields
- Decrease environmental impacts caused by excess applied water
- Low labor input for irrigation
- Minimize chemical leaching

3.2. Drone in agriculture:

The application of drones in agriculture started in the 1980s in Japan. The match of drone and agriculture are made in heaven. The drone is also known as Unmanned Aerial Vehicles (UAVs). PwC has predicted that the total market value of drone-powered solutions at over US$127 billion. Drone technology can easily be integrated with existing management practices and this integration able to reduce human labor and time consumption in crop production. According to (Anderson, 2014) a drone can collect information related to the health of standing crops even every hour that is very cumbersome for the human being. Ahirwar *et al.,* (2019) projected that in near future, the drone will capture nearly 80% of the agricultural market. Drones can be used in entire crop life as a complement of various farm operation: Some uses of the drone are enlisted below:

[1] Soil health analysis: Soil health inspection is very important at the start of crop cultivation as well as the crop cycle. The drone is the most suitable instrument in this regard. Drone generates precise 3-D maps of soil which use to interpret soil health. It enhances the precision of management practices.

[2] Crop spraying: Fusing of LiDAR (Light Detection and Ranging) technology enables a drone to read and understand the topographical and geographical variation of the field. Drones are also able to scan and sense the nutrient deficit in the field, thus spray the optimum amount of chemicals. Ahirwar *et al.,* (2019) find that aerial spraying is five times more effective with drones than with the traditional method of spraying.

[3] Health assessment: It is very crucial to know your crop's health continuously. Drone inspects the crop by using both visible and near-infrared light and produces multispectral images. By analyzing these images we find crop health in real time. Timely treatment of the problems can notably reduce crop yield.

3.3. Face recognition systems for domestic cattle

One of the remarkable work has been done by AI by developing global standards for cattle recognition. The missed or exchanged cattle, inaccurate insurance claims, and cow's reconfiguration at abattoirs are worldwide problems. In dairy departments, face recognition of cows can supervise all key elements of behavior in a group individually, and also rating and feeding can be done as per body condition. Because of the invention of this technology, this is possible to correct a lame cattle, before it indicates the symptoms of lameness, it can save weeks of slower growth.

3.4. Driverless tractor

Autonomous tractors can automatically detect farm boundaries and plowing position. Driverless tractors are programmed to operated farm operations without more manpower intervention Self

Fig. 9. Face recognition systems for domestic cattle

(Source: Innovation News Network, 2020)

driving tractor technology has the capacity to simplify on-farm activities and provide farm employees and their families with a safer and less demanding working climate.

3.5. Precision farming:

Traditional farming is based on the concept that fields are homogeneous in nature. So a uniform amount of agrochemicals are applied in whole fields. But in reality, most of the fields evidence heterogeneity in terms of fertility and compositions. This scenario is taken under consideration in precision farming. In precision farming, different rates of inputs (irrigation water, fertilizers, pesticides, *etc.,*) are applied based on the requirement. Precision farming is the sum of concepts Right Place, Right Time, Right Product, and Right Amount. The cycle of precision farming can be represented by the following diagram.

Basic technologies required for precision farming are (Comparetti, A., 2011)

Satellite Positioning System for Geo-referencing position in which the field parameters are measured (Comparetti, 2000);

Sensors for observing the field parameters (Comparetti, 2000);

Devices for supervising different rate of application farm input

Software for controlling sensors and devices.

Crop simulation models for studying the relationship between parameters and crop growth.

AI has the potential to make the dream of precision farming true by implementing automated sensors and devices.

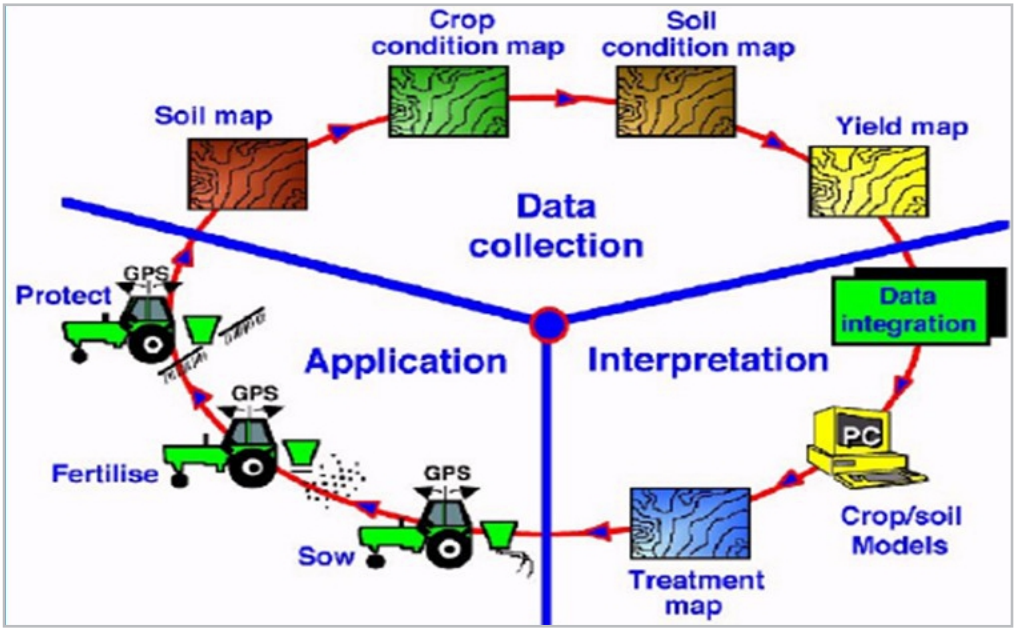

Fig. 10. Precision farming *(Source: Comparetti, A., 2011)*

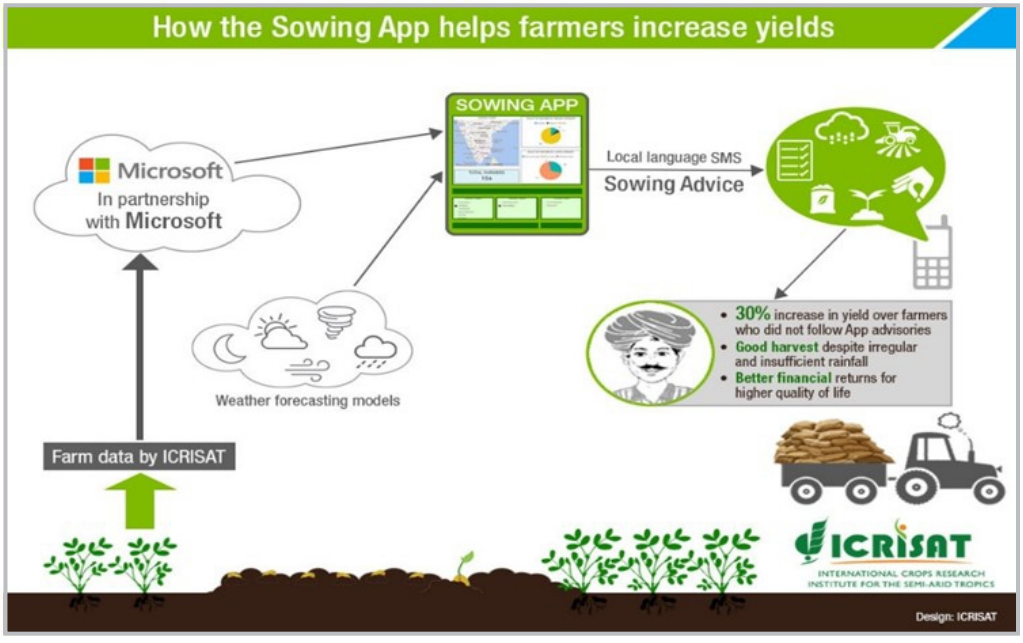

Fig. 11. Sowing app (Microsoft, ICRISAT) *(Source: ICRISAT)*

4. Artificial intelligence (AI) in indian agriculture

4.1. Sowing app (Microsoft, ICRISAT)

For Andhra Pradesh farmers, a mobile app has been developed with an interactive graphical dashboard by Microsoft India in collaboration with International Crops Research Institute for Semi-Arid Tropics (ICRISAT). This app suggests farmers regarding suitable sowing date of crops by observing the local conditions and weather indicators (Durga, 2020).

The app is built on competent cloud-based predictive analytics to help the farmers by giving valuable insights and useful information that aim to lessen crop failure and yield loss.

4.2. Soilsens

A potential technology based on AI emerges with a solution to monitor the soil health, called "Soilsens" (Busch, 2012). This helps the farmers to decide on the right type and the right amount of input factors at right time. Proximal Soilsens Technologies Pvt. is the manufacturer of this innovation. This is incubated with the sponsorship of the Ministry of the Department of Science and Technology (DST) and the Ministry of Electronics and Information Technology at IIT Mumbai. The device is made up of four sensors including a soil moisture sensor, soil temperature sensor, atmospheric humidity sensor, and air temperature sensor. Based on the data from the sensor, the mobile app gives suggestions to farmers about the optimum amount of fertilizer and irrigation to be applied.

The system Soilsens help the farmers to avoid over irrigation, protect the farm from pest and disease infestation, prevent nutrients drain from the soil, and offer voluntary suggestions and advisories.

4.3. Plantix app

Plantix is an advisory and predictive services provider app which also used to identify crops and also crop diseases (Soam *et al*., 2018). A deep learning technique named Plantix, which detects possible anomalies and nutrients deficits in soil has been produced by Berlin-based agric software startup PEAT. The investigation has been done by a deep learning algorithm that identifies the soil defects and plant pests and diseases.

4.4. Jivabhumi

Jivabhumi is an agricultural technology platform that reforms the agricultural marketing channel. It enables the farmers to contact to reach consumers and comes to the business. Jivabhumi allies with producers, a community of farmers, consolidate agricultural outputs, and make

Fig. 12. Plantix app *(Source: Krishi Jagran, 2018)*

Fig. 13. Jivabhumi platform *(Source: Jivabhumi)*

it detectable to exploit the FOOTPRINT TRINT framework allowed by BLOCKCHAIN (Kumar *et al.*, 2020). Jivabhumi considers both B2C (Business to Consumer) and B2B (Business to Business).

Jivabhumi is accelerated by India's leading start-up incubator such as YES Scale Accelerator, a-idea NAARM, NSRCELIIMB, KIIT TBI.

4.5. Gobasco

Gobasco is an agri-tech platform based on the insight of artificial intelligence that addresses the agri-supply chain problem. This technology helps agricultural SMEs (Small and Medium enterprises) by offering fruitful data. It also provides the agricultural industry with logistics enhancement and yield estimation solutions.

4.6. Predictive analytics

Climate change creates a more adverse condition for the farmers as uncertainty in weather conditions makes traditional knowledge ineffective and inefficient. In order to overcome these lacunae, farmers need a precise forecast value of weather parameters and different undercities like disease and pest infestation. More accurate forecasts could enable farmers to opt for suitable cultural practices of crop management. Predictive analytics based on AI techniques predict the future behavior of the environment by analyzing historical figures. Together with satellite measurements, climate modeling AI in agriculture can be used to foretell climatic patterns to analyze farm sustainable growth and analyze the existence of pests and diseases in farmlands (Coble *et al.*, 2018).

5. Challenges of AI adoption and diffusion

From the above discussion, we can infer that the next revolution in the agriculture sector due to artificial intelligence is not so far. But there is still exist a lack of adoption of artificial intelligence in many countries including India. In general, the adoption and diffusion of new technological innovations within the agriculture domain

are very difficult. There are many obstacles in implementing AI-based innovations in farming, including:

High cost of implementation

AI-based machines, sensors, *etc.,* are costly for small and marginal farmers. Repair and maintenance charges also required huge money. In Indian, approx. 80% of farmers are small and marginal farmers. So budgets are one of the major constraints to adopting AI in agriculture.

Access to the internet

One of the major barriers to adopting new technology is internet access. The big challenge to AI in agriculture is the instability of the IT sector in India. Merely 34.45% of the total population of India are currently having access to the internet (Statista, 2020).

Security of information

Data security and integrity also major issues for adopting AI in agriculture. Data is new wealth. Although the concern of security information is well addressed by AI, there is some myth regarding this.

Infancy of autonomous devices

The use of an autonomous machine in agriculture is yet in infancy. Only in two sectors like greenhouses and dairy farms, the use of an autonomous machine is frequent but in other sectors, it is a matter of concern.

According to Niti Aayog, the major challenges are

a) Lack of supportive environments for data

b) Poor intensity of study on AI

- Key studies on basic technology
- Turning core studies into business implementations

c) Insufficient access to AI training, workforce and skills prospects

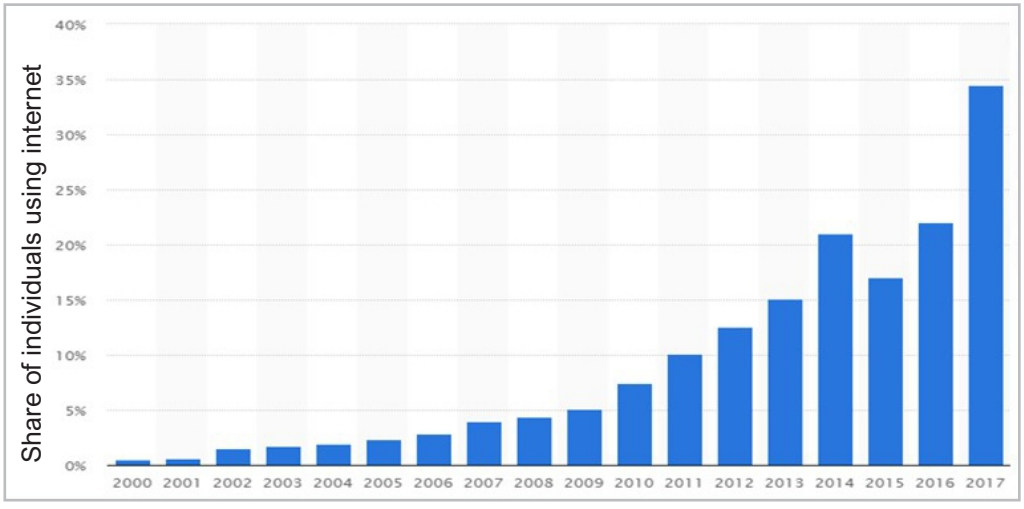

Fig. 14. Statistics related to internet use in India *(Source: Statista, 2020)*

d) Heavy cost of capital and little knowledge of AI adoption in enterprise applications

e) Vague laws on confidentiality, protection, and ethics

f) Unappealing scheme for intellectual property to promote the study and the implementation of AI (Niti Aayog discussion paper, 2018).

There are also other challenges present to adopt AI like social acceptance, insecurity in employment, *etc*. In order to allow them to surpass the efficiency of innovation, the latest evolving AI innovations will require work and effort.

6. Conclusion

In national strategy for artificial intelligence, in order to enforce AI Initiatives in agriculture, the Niti Aayog, Government of India has collaborated with many top AI based players. India's agricultural industry that constructs the bedrock of Indian's economy requires multi-layered innovation infusion and cooperation among the many stakeholders. And requiring the government to serve the key role in the development roadmap for implementation of AI agriculture. Doubling Farmer's Income as a national agenda has been prioritized by the Govt of India; concerning production boosting, it puts significant emphasis on supply chain insights in farming and business growth. While Artificial Intelligence provides tremendous possibilities for agricultural use, there is still a lack of awareness of agriculture in several parts of the globe through high-tech artificial intelligence methods.

In addition, the insufficient supply of AI resources, incentives for resources and skills, high labor costs, and poor knowledge are the constraints of the implementation of AI in agriculture. Overall, AI may be a wonderful gift to the agriculture industry, which is hugely reliant on sometimes volatile environmental conditions. Sensors for plant and soil analysis, as well as AI and deep learning software for predictive modeling, are used by different businesses. Due to the tremendous value, it can bring, even more, AI applications in agriculture are expected to emerge in the coming years.

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